2004 Annual Project Summary
Rupture history of the San Andreas fault at Van Matre Ranch, Carrizo Plain, California: Collaborative research with the University of California, Irvine and Arizona State University

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Investigations undertaken

The Carrizo Plain has been one of the most productive sections of the San Andreas fault for paleoseismic research (see **Figure 1** for significant paleoseismic sites), and we think it may hold the potential to reveal a paleoseismic record approaching Pallett Creek (PC) in number of earthquakes, and exceeding Pallett Creek in measurement of slip per event and slip rate. Our long-term goal is to document this record. This report summarizes a portion of our work at the Van Matre Ranch (VMR) site in the southern Carrizo Plain during the 2004 project year.

A set of well-preserved channels are offset across the San Andreas fault at the Van Matre Ranch site (35.154N, 119.700W) in the Elkhorn Hills area of the Carrizo Plain. The Van Matre Ranch site (**Figures 1 – 4**) is in the southern Carrizo Plain, 18 km southeast of previously developed and spatially clustered paleoseismic sites at Wallace Creek (Sieh and Jahns, 1984; Liu, 2003), Phelan Creeks (Sims, 1994), Phelan fan (Grant and Sieh, 1993) and Bidart fan (Grant and Sieh, 1994). Early work at the Van Matre Ranch site focused primarily on measuring offsets (Sieh, 1977,1979) (**Figure 2a**). In the early 1990s, two efforts gathered more data at the site. In 1991, Sieh, Grant and McGill had large scale aerial photography flown and a topographic map produced photogrammetrically for the site (Figure 2). In 1993, Arrowsmith worked with John D. Sims and his group (USGS) at the site (**Figure 2c**) to investigate the quality of the stratigraphy and to test models for channel responses to earthquake offset (Sims, et al., 1993). They excavated 7 trenches, shown on Figure 2c.

In the 2004 project year we opened 3 new trenches (T6', T8 and T9) and reopened the original trenches T2 and T3 for detailed logging, stratigraphic correlation, and sampling for radiocarbon dating. We surveyed the site to tie all the trenches into the same coordinate system (**Figure 4).** An example log of Trench 8 (T8) is shown in **Figure 5**. We also began a new initiative by our group: to conduct our own radiocarbon dating under the supervision of Dr. John Southon, at UCI's new Keck AMS facility devoted to carbon isotopes. We collected 17 samples and dated all of them, at significantly reduced cost. We are currently preparing to present results at the Fall AGU Meeting, and beginning work on a manuscript which we hope to submit to *BSSA* or *JGR* in early 2005.

Results

Full results will be documented and disseminated in early 2005 in our forthcoming manuscript and Final Technical Report. The results are summarized in our AGU abstract, reprinted below:

Fall 2004 AGU Abstract (Authors: Noriega-Carlos, Grant, Arrowsmith and Young)

> To understand the spatial and temporal variation in fault slip it is important to improve the spatial coverage of slip and slip rate measurements along major active faults. A set of well-preserved channels are offset across the San Andreas fault at the Van Matre Ranch (VMR) site (35.154N, 119.700W) in the Elkhorn Hills area of the Carrizo Plain. The fault zone and offset channels at VMR were exposed by excavation in 1993 and 2004. This study included one fault-perpendicular and 5 fault-parallel trenches that exposed the buried thalwegs of several offset channels. Seventeen samples were collected from channel margin deposits for ^{14}C dating and survey data was taken for accurate offset measurement of the buried thalwegs and geomorphic channels. The geomorphic history of the site is well manifested in the excavations with clear evidence for initial incision of the channels into Plio-Pleistocene fan units that were typically heavily bioturbated. The channels then back filled and the stratified channel sediments grade laterally into clayey silts. The buried thalweg of the currently active channel is offset 24.8 m, while the geomorphic offset is 27.6 m (qualitatively defined conservative uncertainties on offsets are +/- 1m). The thalweg of the first beheaded channel is offset 48.8 m with a geomorphic offset of 51.8 m. The geomorphic offset of the second beheaded channel ranges from 71.9 to 79.0 m. There are no ages associated with these channels. The median dates of samples from the clayey silts in the currently active channel margin range between A.D. 1221 and 1108, implying a 34.7 mm/yr slip rate. The significance of the samples ages is dependent upon interpretation of the sediments in which they were collected. They were collected from clayey silts which are either colluvium, washed down from adjacent hill slopes, or autochthonous alteration of the channel deposits by pedogenic processes (largely burrowing). If the samples were derived from colluvial processes, the ages of the samples would provide a maximum slip rate. However, if the samples were derived from older channel sediments, then they would indicate a slip rate minimum. This preliminary slip rate is consistent with the measured slip rate at Wallace Creek, approximately 18 km to the northwest where Sieh and Jahns documented a late Holocene slip rate of approx. 33.9 +/- 2.9 mm/yr, and with the regionally assumed 35-mm/yr rate derived from decadal time-scale geodetic measurements.

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Non-technical Summary

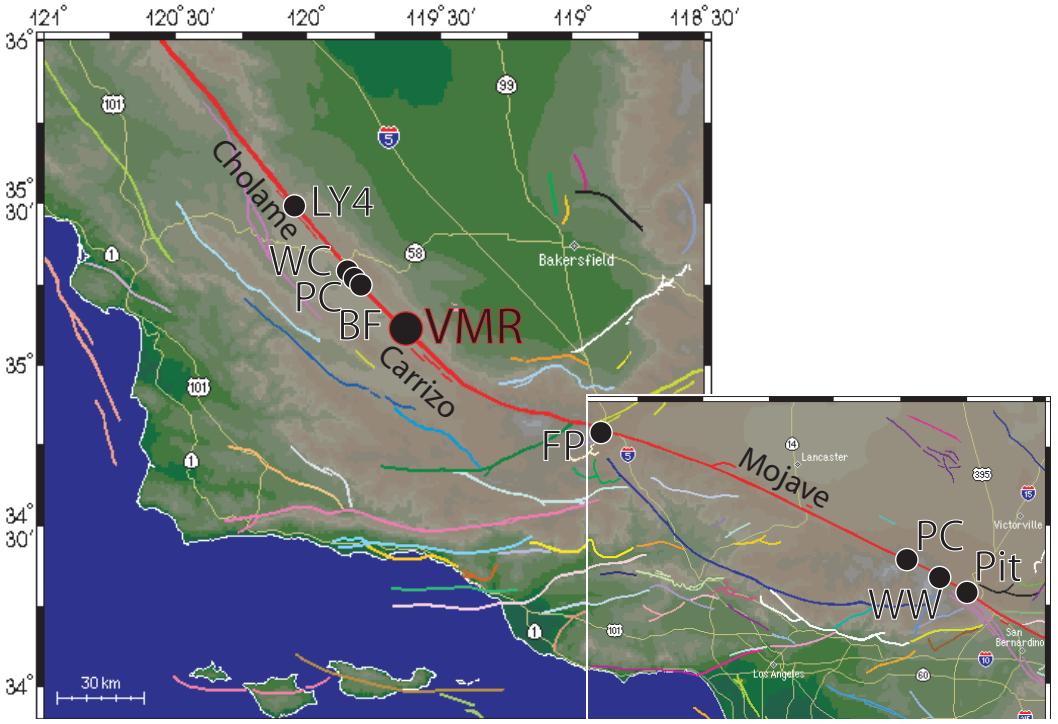
Because of its great length and high slip rate, the San Andreas fault is the largest source of seismic hazard in California. The past behavior of the fault is the best indicator of future earthquake potential. The goal of this project is to measure surface displacement, or fault slip, from past earthquakes to quantify the average production rate (slip rate) of large earthquakes on the San Andreas fault in the Carrizo Plain. The data are collected by excavating the fault zone and mapping it at a location where it has displaced several small stream channels.

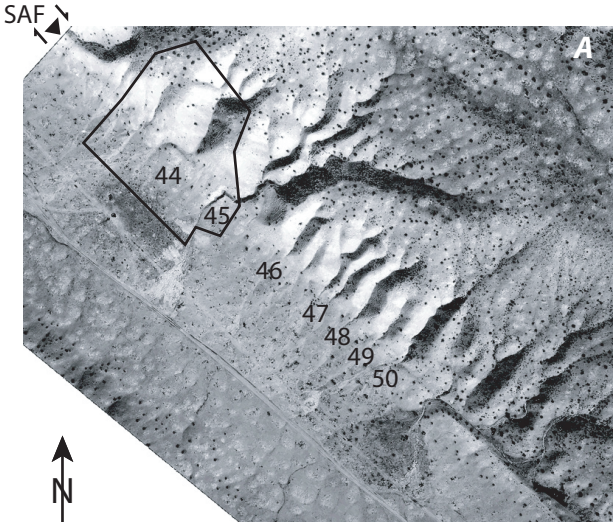
Reports published

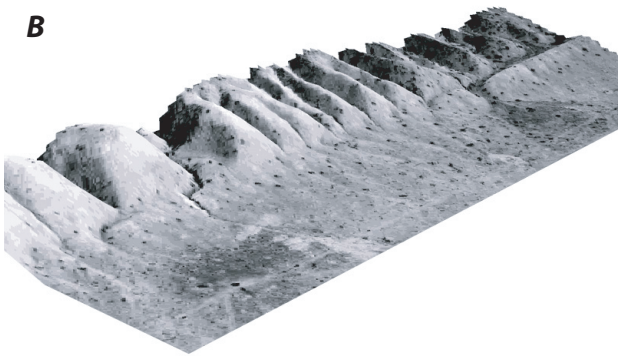
Noriega-Carlos, G. R., Grant, L. B., Arrowsmith, J R. and J. J. Young (2004). Stream Channel offset and preliminary slip rate on the San Andreas fault, at the Van Matre Ranch site, in the Carrizo Plain, California, *Eos Trans. AGU*, 85(47), Fall Meet. Suppl., Abstract G11A-0772.

The data are available from this site: http://activetectonics.asu.edu/carrizo/VMR/

Figure 1. Location map of major paleoseismic sites along the south-central SAF (red line). Van Matre Ranch (VMR) is located in the central portion of the Carrizo section of the SAF; south of LY4-Cholame, Wallace Creek study site of Liu, 2003 (WC), Phelan Creeks (PC; Sims, et al.), and Bidart Fan (BF; Grant and Sieh, 1994). The Frazier Park site of Lindvall, et al. (2002) is along the northern portion of the Mojave section which is well characterzed to the southeast at Pallet Creek (PC; most recently by Biasi, et al., in press), Wrightwood (WW; Fumal, et al., (2002)), and Pitman Canyon (Pit; Seitz, et al.). Other Southern California SAF sites (Plunge Creek, Burro Flat, and Thousand Palms) are located southwest of this map. Base comes from the SCEC fault map (http://www.scecdc.scec.org/faultmap.html).







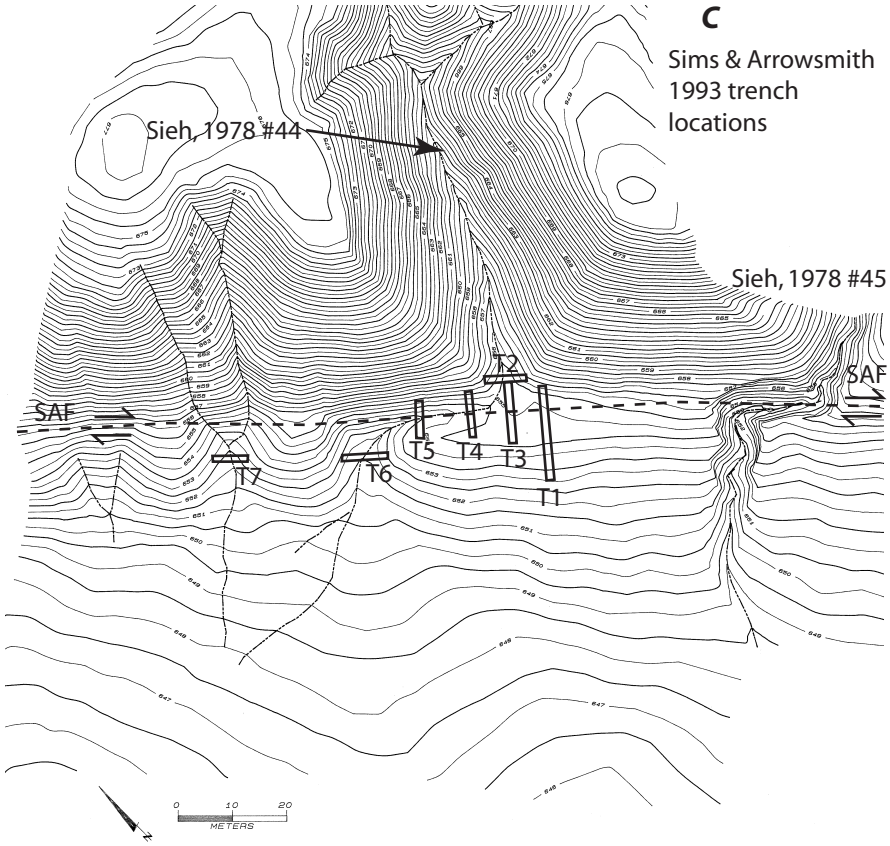
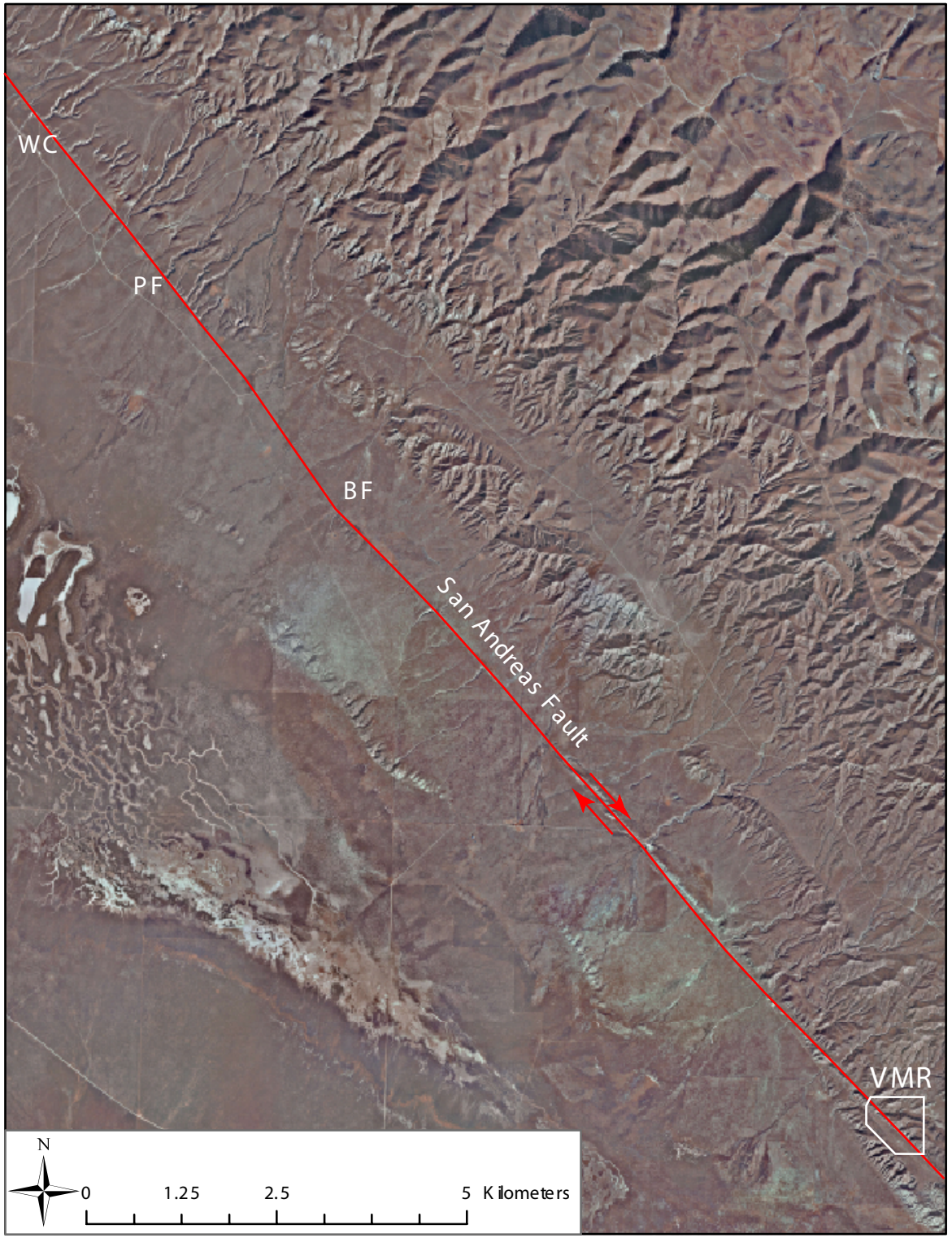


Figure 2. Aerial photographs and topography for the Van Matre Ranch site. A) Rectified aerial photograph (3-9-1991; original scale 1 : 3,000) showing the clear trace of the SAF with numerous 1-10s of meter offsets (those studied by Sieh, 1978 are shown with corresponding numbers). B) Oblique view of aerial photo draped on photogrammetrically produced elevation data (view to ESE; photos and topography from Kerry Sieh; images produced by Miryha Gould at UCI). C) 1 meter contour interval map of Sims and Arrowsmith 1993 study site (shown as polygon in A) with trench locations spanning the offset channel complex. We have re-excavate several of these trenches, checked and updated logging, reconstructed offset channels with establishment of complete 3 dimensional geometric control, and sampled the stratigraphy for ^{14}C dating (topographic surveying by J. C. Hamilton, J R. Arrowsmith, and C. Garvin and plotting by Hamilton).



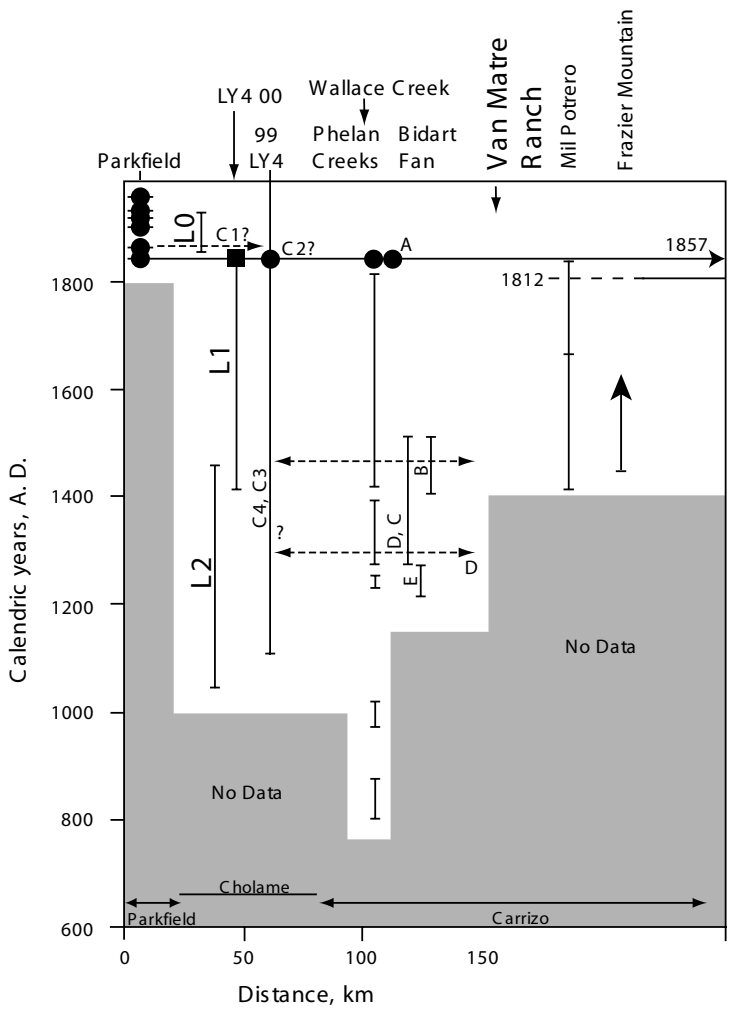


Figure 3. A) Aerial photography (from AirPhoto USA) of the central Carrizo Plain showing the locations of major paleoseismic study sites (WC, Wallace Creek; PF, Phelan Fan; BF, Bidart Fan; and VMR, Van Matre Ranch). B) Event correlation diagram for the Parkfield, Cholame, and Carrizo segments of the SAF (modified from Young, et al., 2002 and Liu, 2003). The Van Matre Ranch site is located in an important position in the south-central Carrizo Plain between the cluster between WC and BF and Mill Potrero and Frazier Mountain to the southeast. Data are from: The historic Parkfield record (e.g., Bakun and Lindh, 1985), LY4-99 (Stone, et al., 2002), LY4-00 (Young, et al., 2002), Phelan Creeks (J. D. Sims, personal comm.), Bidart Fan (Grant and Sieh, 1994), Mil Potrero (Davis, 1983), and Frazier Mountain (Lindvall, et al., 2002).

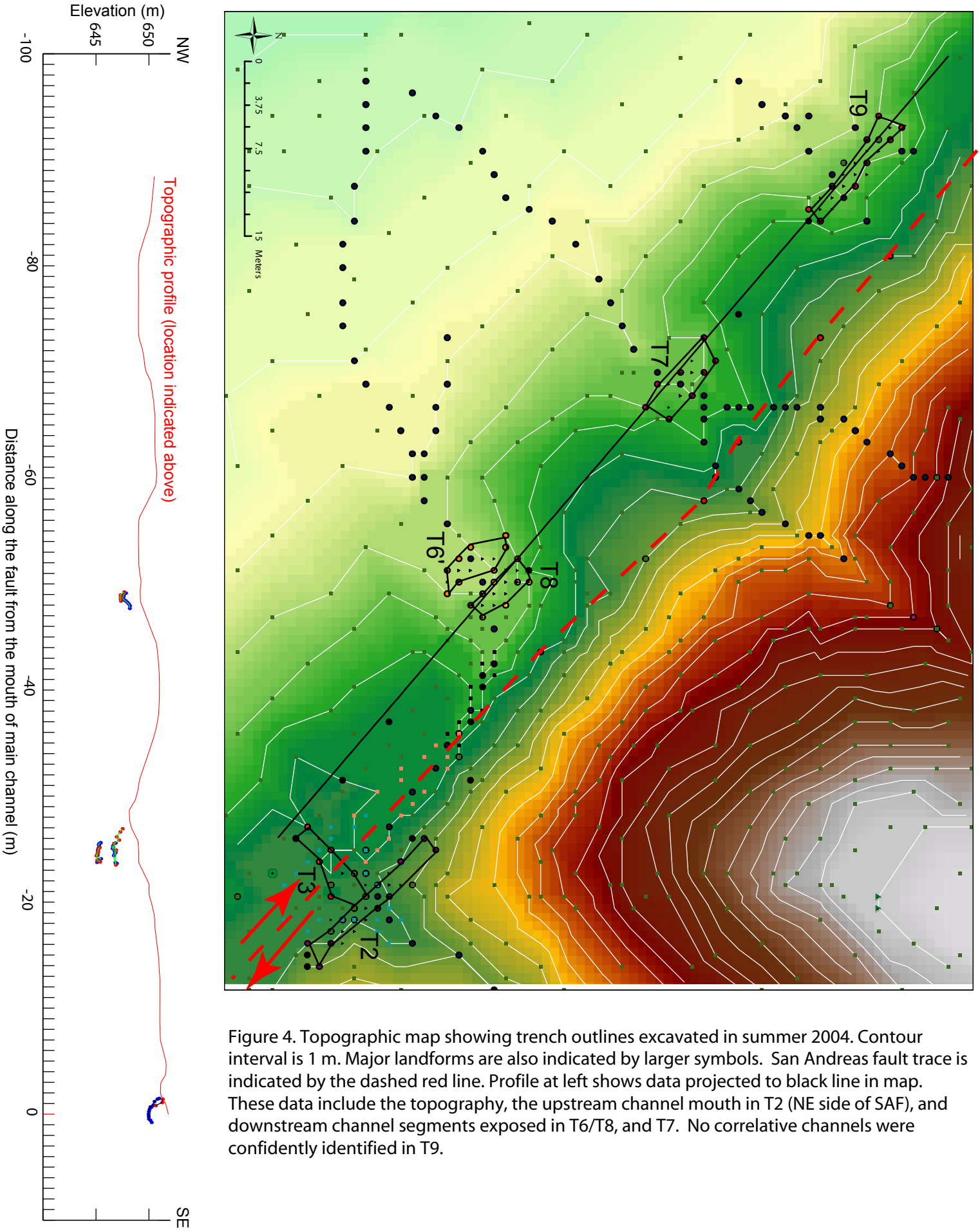


Figure 4. Topographic map showing trench outlines excavated in summer 2004. Contour interval is 1 m. Major landforms are also indicated by larger symbols. San Andreas fault trace is indicated by the dashed red line. Profile at left shows data projected to black line in map. These data include the topography, the upstream channel mouth in T2 (NE side of SAF), and downstream channel segments exposed in T6/T8, and T7. No correlative channels were confidently identified in T9.

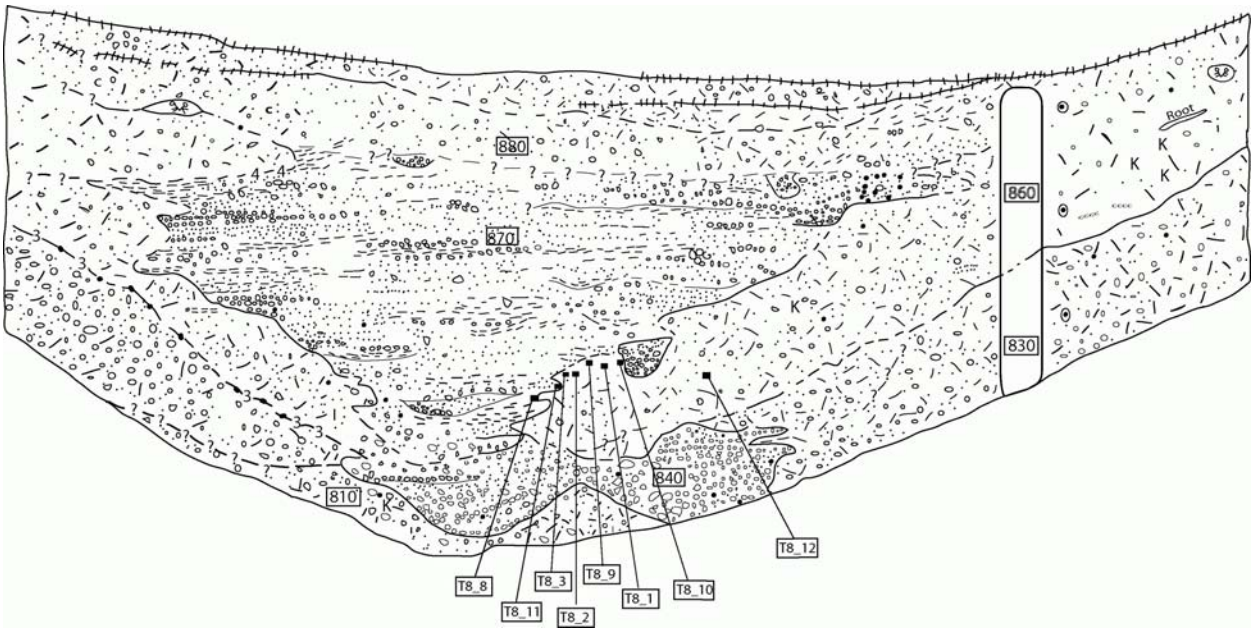


Figure 5
Lithologic log of the northeast wall of Trench 8 (T-8). See Figure 4 for location. The locations of samples collected for radiocarbon dating are marked by solid squares, with sample numbers in callout boxes. Units 810 through 880 are numbered, in boxes, according to stratigraphic position and relative age. Coarse, stratified gravels in units 840 and 870 are interpreted as channel fill deposits. The channels were cut into units 810, 820 (not labeled), and 830, which are interpreted as colluvium. Unit 860 is a clayey silt deposit containing most of the radiocarbon-dated samples. It could be either colluvium, washed down from adjacent hill slopes, or authochthonous alteration of channel deposits by bioturbation and other pedogenic processes.